Overcoming affective barriers to mathematical learning in practice

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Abstract

Maths anxiety is an acquired fear of mathematical situations or subjects which stops the brain being able to process maths effectively or even at all. This situation-specific anxiety occurs as a result of one or many negative experiences with maths and is thought to affect a large proportion of people. Statistics anxiety, which is related to maths anxiety, has been shown to be a strong predictor of poor performance in research methods courses and can affect a student's ability to use statistical software and understand research articles.

Negative experiences condition the brain to view maths as a threat so students with maths anxiety will generally opt out of maths or statistics. Where this is not possible, avoiding studying until the last minute is a common occurrence, leading to poor performance, which reinforces belief that the student cannot do maths. For some, previous experiences are such that even the word 'maths' triggers fear which results in self-safeguarding by avoiding even maths support centres or maths anxiety seminars.

This paper discusses initial approaches which can be implemented within an individual support setting to start the process of overcoming affective barriers to mathematical learning. The process of addressing maths anxiety includes: increasing awareness of maths anxiety; developing approaches which enable learners to overcome triggers and setbacks (mathematical resilience); providing non-threatening, inclusive, positive teaching experiences with maths and statistics and, perhaps most importantly, developing agency within each learner that enables them to suitably self-safeguard.

Key words: mathematics anxiety, statistics anxiety, avoidance, awareness, mathematical resilience, statistical resilience, safeguarding, affective barriers.

1. Introduction

Mathematics anxiety, including statistics anxiety, is acquired, prevalent, disabling and treatable. It is possible to work with learners to prevent anxiety developing in the first place, or to arrest and reverse its development. Without awareness of the prior experience and needs of maths anxious students, it is also possible to add to the previous trauma inadvertently.

The authors have previously developed sessions involving 1 day, 4 day, or half-day and 1 hour workshops for staff and for students (see, for example, Johnston-Wilder et al., 2016; Marshall et al., 2017) but there is also a need to work 1:1 with learners with a more immediate need. A 1:1 mathematical resilience intervention for maths anxious colleagues and students has been developed (Johnston-Wilder, 2017) which may take several sessions. This paper will discuss the essential ingredients of these sessions and how they were adapted for use in a support centre.

2. Essential ingredients

Addressing maths anxiety and developing mathematical resilience is best carried out over one or more sessions at the beginning of a course involving mathematics or statistics, or during a course, but not usually close to an examination because test anxiety is an additional confounding condition that frequently co-occurs with maths anxiety.

2.1 Listening for prior experience

For 1:1 intervention sessions (Johnston-Wilder, 2017), the participants were recruited after being identified as suffering from maths or statistics anxiety. In the first session, after introductions and the agreement of some ground rules, such as confidentiality, each participant was invited to explain what they hoped to get out of the intervention.

The participant was then invited to share their personal maths story, i.e. their previous experiences with maths, good and bad. Sadly there were some participants who could not recall even a single example of a good experience with maths and some personal maths stories can be quite shocking. Many had been told that they are 'stupid' or that they are 'never going to pass' by teachers or parents, behaviour which elsewhere is recognised as a form of emotional abuse. One participant remembered being gripped round the neck and shouted at when a parent had become exasperated. The process of recognising these experiences as harmful and not about mathematics or about them was for each participant a first step to reducing maths anxiety.

Whilst the participant was giving their account, Johnston-Wilder listened out for instances of exclusion and harm, including anticipatory harm. Telling the personal maths story was often a surprisingly emotional experience, so each session took place in a safe, private space.

2.2 Understanding anxiety and its impact

The intervention moved on to explaining maths anxiety in terms of the emotional part of the brain and how that impacts on learning mathematics or statistics, and then introducing the growth zone model and strategies to self-safeguard. Maths and statistics anxiety are situation-specific anxieties and the approaches described here have also be applied to anxiety triggered by other situations such as writing (Findon & Johnston-Wilder, 2017).

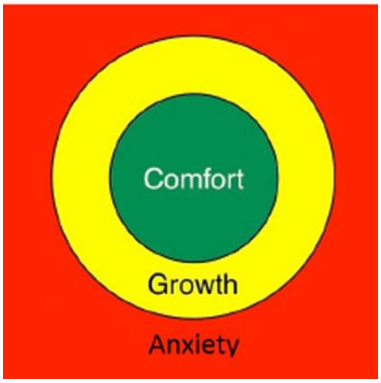
Negative or painful experiences in the past such as humiliation or exclusion mean that the brain views maths as a threat. The role of the amygdala within the brain is survival; to immediately recognise threatening situations by similarity to previous experiences and initiate the 'fight or flight' response before the actual threat can be interpreted more fully by

the cortex. The natural reaction is to avoid any situation triggering such a response which helps explain the usually ineffective 'maths avoidance' strategy implemented by many. If the threat is not addressed agentically, anxiety develops and this anxiety can interfere substantially with working memory making maths seem considerably harder than it actually is.

It is helpful to use a picture or a model to explain the impact of maths anxiety on the brain. The use of brain images or models has been shown to make psychological arguments more persuasive (McCabe & Castel, 2008; Siegel, 2012). For example, Siegel's hand model of the brain (Siegel, 2012) can be used to help the client understand how the brain 'flips' to survival mode when a threat is perceived by the amygdala based on prior experience, and why the client may feel stupid when faced with maths. Students and colleagues have said they find the hand model of the brain and/or the use of brain scan pictures to describe the impact of maths anxiety gives them new insight and awareness.

Given the extent of previous negative experiences, particularly around issues of humiliation and exclusion, it is not surprising that anger or tears can be involved before clients fully re-engage in maths or statistics. Similarly, recognising that the level of psychological pain or 'psych-ache' was avoidable can be distressing.

2.3 Introducing the growth zone model



In order to become mathematically resilient, students need to feel safely challenged, expect to make some mistakes, seek support from peers or maths support when needed and, above all, persevere. Introducing the growth zone model (Johnston-Wilder et al., 2016), as shown in Figure 1, helps students recognise the different emotions involved in learning and distinguish between the productive nervousness of the 'growth zone' and the disabling anxiety associated with the 'anxiety zone'. Understanding and recognising emotions in these zones is a prerequisite to learning to manage these emotions. The anxiety zone is linked to Siegel's 'flipping'. Many students with maths anxiety may initially flip straight from the 'comfort zone' to the 'anxiety zone' but, within a supportive, positive teaching environment, can learn how to work at mathematics successfully and develop a belief that they can progress.

Mathematical (statistical) resilience is what it takes to go into and stay safeguarded in the growth zone, namely, a growth mindset, value, inclusion and supported, agentic struggle (Johnston-Wilder et al., 2016). It is useful for students to recognise which zone they are in and the feelings associated with each zone.

It is worth noting that for some participants, this has been far enough for one session. Either next or in a subsequent session, clients have then gone on to experience maths as ALIVE: accessible, linked, inclusive, valued and engaging (Johnston-Wilder et al., 2016); for some this was the first such experience, as much school maths is experienced as the opposite (Nardi and Steward, 2003). In the past, the authors have subsequently worked

with learners on building a personal tables square, making a Toblerone-shaped ruler to represent fractions, decimals and percentages, or using tasks from the book 'Developing Thinking in Statistics' (Graham, 2006).

2.4 Coaching strategies

Each client came to recognise their brain as seeking sense, meaning, and purpose. Their previous experiences and their personal maths stories were used with the hand model and the growth zone model to reframe prior experiences as unnecessarily emotionally harmful.

Strategies were developed for avoiding and for exiting the anxiety zone. For example, when faced with a list of tutorial or examination questions, clients have gone through the paper colour-coding the questions by zone by the effect the question has on their emotions, and then seeking help with the 'growth' questions, avoiding the anxiety-triggering questions at this stage. Clients have learned to exit the anxiety zone by breathing strategies such as longer out-breaths (5/7 breathing) which is a direct route to calming the amygdala. Other techniques for addressing anxiety have been found help, such as taking a break, listening to calming music or going for a walk; each client has developed a repertoire that works for them and come to understand that if they are in the anxiety zone learning is at best inefficient.

Sessions were repeated sometimes up to 3 sessions until the client felt able to self-safeguard when learning mathematics or statistics. Each client has gone on to further progress with maths or statistics.

3. In a support centre in reality

Building mathematical resilience effectively may take time. In reality those working in maths support are more likely to come across maths or statistics anxious students with an imminent deadline in a busy support centre. Whilst there may not be time to use the full support process described above, elements have been used successfully within this setting.

3.1. Recognising maths anxiety

The first step is the recognition of the signs that a student is suffering from maths anxiety and acknowledgment of the impact this is having on their performance and study behaviour. Students with high levels of maths anxiety often visit maths support centres close to a deadline and have even admitted that they have been putting the work off almost hoping that it will just go away (avoidance is a form of self-safeguarding).

Anxious students struggle to take anything in and often repeat things like "I failed my GCSE maths *n* times", "I don't understand any of it!", "Everyone else gets it" or "I can't do maths" rather than listening. They may also display signs of general anxiety, appear tearful, frustrated or even angry. Many students appear anxious close to deadlines so ascertaining the root of the stress should be the first step. Asking questions such as "How anxious do you feel about maths on a scale of 1-10?" and whether they are equally anxious about their other modules can help decision-making. The recognition of maths anxiety and that it is the

anxiety that prevents success rather than lack of innate ability is the first step to overcoming it (Uusimaki and Kidman, 2004).

3.2. Beginning to build maths resilience

Printable resources were developed for staff and students (https://www.sheffield.ac.uk/mash/anxiety) to act as a useful starting point for helping explain the impact of maths anxiety and the growth zone model to anxious students. The use of the growth zone model during support sessions helps students learn to quickly identify when they are in the anxiety zone and need to address the anxiety before continuing.

Once maths anxiety has been identified and acknowledged, a learning support plan can be developed to deal with the impending event. In the first session, discussion is centred around what can be realistically achieved in the available time frame which has helped the students relax; the importance of developing a longer term approach with their future maths or statistics requirements has been stressed.

Receiving individual maths support can be successful at reducing anxiety as sessions are tailored to the individual, allowing enough time for student enquiry and conceptual development at their own pace. Being able to ask questions without fear of humiliation and receiving immediate feedback reduces the time it takes for students to reach a desired level of understanding and can reduce the negative impact of maths anxiety (Núñez-Peña et al, 2015), unless it is triggered during the session. It is important to start at the point where students are comfortable and build from there (scaffolding). Although students have often repeatedly said they don't know any maths or statistics; asking students to 'say what they see' or explain simple charts has been a useful starting point. Students have also been encouraged to recognise the existing mathematical or statistical thinking they use every day (e.g. using Graham, 2006). Triggering of anxiety can happen very suddenly, even when a student seems to be progressing, resulting in sudden tears or anger. Giving the student colour-coded cards has been found effective in supporting communication about emotions, alerting staff or peers to the need for preventative action.

4. Conclusion

Maths anxiety is prevalent, disabling and commonly observed in maths support centres. In much the same way as a practitioner would recognises short-sight as an impairment to progress, and refer a student for an eye test if a problem were recognised to be vision-related, it is important to become able to recognise someone with maths anxiety and to understand that their progress is impaired until they receive explicit help for the maths anxiety. By recognising when a student's anxiety is impacting their progress, and by using some of the techniques described in this paper, staff can assist students with becoming mathematically resilient and successful learners.

Colleagues who teach or support maths, whilst not counsellors, may also benefit from further development of listening and coaching skills to build mathematical resilience and increased awareness of resources that provide tasks which can be experienced as ALIVE.

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Figure Legends

Figure 1 Growth zone model